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TO

EDWARD G. JANEWAY, M. D.,

AS A TOKEN OF RESPECT FOR HIS GREAT LEARNING

AND

IN ADMIRATION OF HIS SUPERIOR SKILL

AS A DIAGNOSTICIAN,

THIS SMALL VOLUME IS DEDICATED

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PREFACE.

FROM the large amount of literature upon the subject of medical electricity, the author has endeavored to select and classify such facts and principles as would present to the student and general practitioner a clear, short, and yet comprehensive view of this important and so illy-understood branch of therapeutics. He believes that a work having the scope thus laid out, will prove of value to the undergraduate and to the physician who have neither the time nor patience to wade through some of the larger treatises on the same subject.

U. S. Army, December, 1886.

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A COMPEND

OF

ELECTRICITY.

INTRODUCTION.

WITHIN the last ten years, Electricity has extended its usefulness with great rapidity. Immense strides have been made in its application to modern improvements in every-day life; so great has been this advance, that this branch of physical science now furnishes occupation for many hundreds of trained minds, and the profession of electrician has many followers. And though in the application of this power to medicine no such phenomenal discoveries have been made as the telephone and the various forms of electric lights and motors, still, the development of the science as applied to medicine and surgery has by no means remained at a standstill;

new uses have been proposed and established by continued observation, and the knowledge and application of this very potent therapeutic measure have very extensively increased of late years.

Notwithstanding the undoubted and great utility of Electricity in medicine and surgery, it is surprising that there still remains a large class of practitioners who rarely employ it, and are apparently content to remain in almost complete ignorance of the subject. This may be explained by the fact, that the busy practitioner is frightened at the prospect of having to wade through large and exhaustive treatises on the subject, and is thus dismayed by the mass of scientific information and of technical terms which he is expected to understand.

The undergraduate also is disheartened upon attempting the study of Electricity from full and lengthy treatises; and though this should not be a reason for completely ignoring the subject, yet as a matter of fact it often forms his excuse for so doing. Hence the necessity arises for concise and short treatises upon this therapeutic resource.

In all the better medical colleges in the country, a knowledge of the subject is required for graduation, and rightly so. What student of medicine would profess to have a good knowledge of Materia Medica, and have omitted studying an important drug, such as belladonna or opium? And yet Electricity cannot be said to occupy a position in Therapeutics secondary to that accorded the drugs just mentioned. Some of its achievements in medicine and surgery stand unrivaled! Its relief of pain, of which Bartholow says, "there is no effect more certain than the power of galvanism to relieve pain," its allaying spasm, and its action in causing a favorable termination in cases of tubal pregnancy—these will serve as examples of brilliant results accomplished by the use of this great physical agent.

Then again, we have not many agents which are credited so often with saving life in failure of the heart and respiration from various causes. Many other examples of the inestimable advantages from the use of Electricity might be cited. Not only in general medicine, but in every specialty it has its frequent applications; and certainly no physician's office can be considered satisfactorily equipped without at least a faradic and a galvanic battery.

It is interesting also to consider the variation in the estimation in which this agent is held by different practitioners, and to solve the causes of the discrepancy in the favor with which it is received by them. There will be found a large portion of the profession who are most enthusiastic in its use, praise it highly and apply it often. Another portion are almost absolute disbelievers; they look with suspicion upon anything with which Electricity is mentioned, and give it no more credit of valuable effects than that of being a good and powerful *placebo.*

The explanation of this difference of opinion will become plain, when it is known that the number of the first grows larger while that of the second class diminishes as the knowledge of the subject increases; in other words, that the lack of confidence in the remedy is usually the result of an absence or insufficient knowledge of the subject. It is no exaggeration to say that a not insignificant number of practitioners make use of the different kinds of electrical currents indiscriminately and without sufficient regard for the laws of Electro-therapeutics which should govern their employment; these are naturally disappointed in the results, and it is not surprising that they look upon the agent with suspicion.

That it is used not infrequently merely to act upon the patient's mind when other therapeutic resources have been exhausted, cannot be denied ; but such use, whether legitimate or not, does not undervalue its status when scientifically employed for well-established indications. To accomplish good results, it must be used according to fixed laws which are simple and easily understood ; and with increased knowledge comes a higher opinion of the value of the remedy, and the disbeliever often changes to an enthusiast.

With a daily enlarging knowledge and a constantly widening field of applicability, no physician can expect to compete with his brethren in therapeutic skill, who fails to secure at least an average acquaintance with the science.

The undergraduate also will find that he cannot afford to be without an understanding of the subject ; for he will become aware that the building of his practical learning upon the largely-theoretical foundation laid during his college years will be very seriously handicapped by the omission to give this subject a fair share of his time. He cannot be expected to read exhaustive works, but a very good idea of the rudiments is to be expected; and since an understanding of medical and surgical Electricity would be difficult, if not impossible, without a knowledge of at least the elements of physical science, so much of the latter as is necessary for the proper assimilation of the text has been inserted.

The use of technical terms employed in expressing the units of force, quantity, etc., has become so common, that an acquaintance with their significance may be considered indispensable; hence their use in the following pages is an advantage, and, being explained in a simple manner, does not give rise to any difficulty in comprehensibility.

CHARLES H. MAY, M. D.

202 East 58th Street,
New York, Jan. 3d, 1887.

CHAPTER I.

PRINCIPLES OF ELECTRO-PHYSICS.

I. MAGNETISM.—Magnetism is the property certain bodies have of attracting iron; substances possessing this power being known as *magnets*.

The *natural magnet* is the magnetic oxide of iron or lodestone, a not uncommon ore.

The *artificial magnet* is made by rubbing a piece of soft iron or steel with a natural magnet, or by the action of galvanism, the piece of metal being placed within a helix of insulated wire, through which the current is made to pass.

Soft iron magnets soon lose their power and are hence known as *temporary magnets*, but steel magnets are *permanent*.

Magnetic substances are such metals as iron, steel, nickel, etc., which are attracted by and are capable of being made magnets. *Diamagnetic substances* are such as are repelled by a magnet.

If a magnet be suspended so as to move freely, it will be found that one end always points to the north, while the other points to the south; hence the terms *north* and *south pole of the magnet.* Bring a second magnet into the neighborhood of the first, and we see that "*like poles repel, unlike poles attract.*"

Armatures are pieces of soft iron used to connect the poles of a magnet; the iron becomes temporarily magnetized, and reacting on the magnet prevents any loss of its power.

Magnetic curves are the imaginary concentric lines radiating from each pole of the magnet, through which experiment has shown the magnetic force to be exerted; the space embraced by these curves is known as the *magnetic field.*

Magnets are of various shapes; that of a bar, or of a horseshoe is usually employed.

A *magnetic battery* consists of a number of magnets bound together with their like poles in the same direction.

II. **ELECTRICITY.**—"Electricity is a powerful physical agent, the existence of which is made known chiefly by attraction and repulsion, but also by luminous and heating effects, and various other phenomena. Its action is excited by friction, pressure, chemical operations, heat and magnetism."

1. **Static or Frictional Electricity** is that form which is excited by friction; it is called static in contradistinction to dynamic or current electricity, because it is not in motion, but is restrained in a state of high tension.

It is supposed that there are two kinds of electricity pervading all bodies, *positive* or *vitreous*, and *negative* or *resinous;* in the unelectrified condition these fluids just neutralize each other, but may be separated by chemical action, friction, etc.

If a glass rod be rubbed with a piece of silk it will attract a pith ball, charge it with positive electricity and at once repel it; if the positively charged pith ball be now brought near a negatively electrified substance, the ball will be attracted, negatively charged by conduction, and again repelled; hence the law, "unlike electricities attract, like electricities repel."

Conductors are substances which offer very little resistance to the passage of a current of electricity through them; those bodies offering considerable resistance are known as *non-conductors* or *insulators.*

The terms are, however, only relative, there being no absolute conductors or insulators. A list of the more important members of each class is here given:—

CONDUCTORS.	INSULATORS.
Water,	India rubber,
Saline solution,	Dry air,
Acid solution,	Dry paper,
Charcoal,	Silk,
Graphite,	Glass,
Metals, etc.	Shellac, etc.

Induction is the influence which an electrified substance exerts over a body placed near but not in contact with it, in decomposing its neutral electricity, attracting the unlike kind to the proximal end, and repelling the like kind to the distal end. The following tables will render clear the differences between induction and conduction.

INDUCTION.	CONDUCTION.
(*a*) Manifested in insulators and conductors.	(*a*) Manifested in conductors only.
(*b*) The inducing body loses no part of its electricity.	(*b*) The conducting body loses part of its electricity.
(*c*) The imparted electricity is of opposite kind.	(*c*) The imparted electricity is of same kind.
(*a*) The body to be electrified must be in connection with the earth.	(*d*) The body to be electrified must be completely insulated.

Dielectrics are insulators through which electricity may act inductively.

Electricity does not penetrate into the interior of bodies; hence the amount of electricity in any given body depends not upon its mass, but upon the amount of surface it affords.

Another peculiarity to be always borne in mind is the marked tendency for electricity to accumulate at and discharge itself from acute points.

Potential is the electrical level of a body above or below that of the earth, which is taken as the standard of comparison and assumed to be zero.

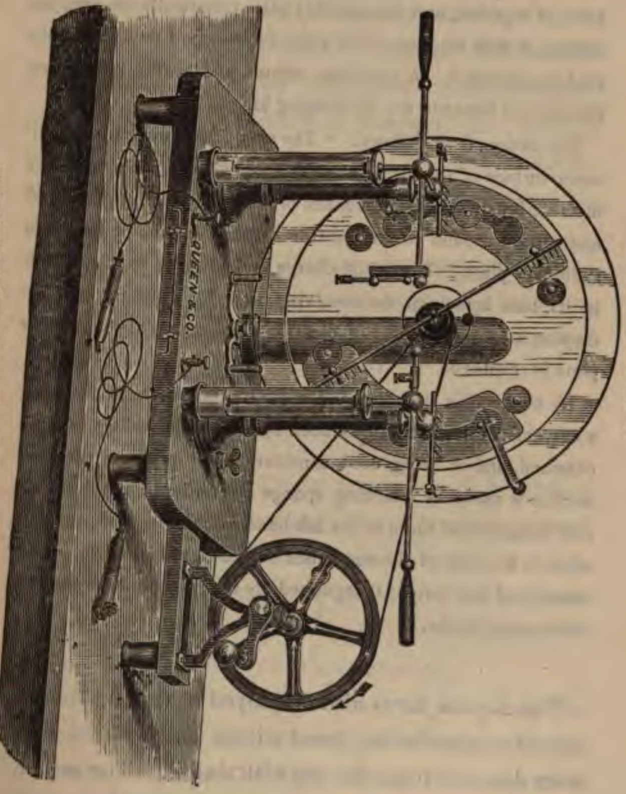
Just as when we place two buckets full of water at different levels above the earth's surface the water readily flows from the higher to the lower, and from the lower to the earth, so electricity flows from the higher level, or potential, to the lower. If the electrical level of an object is above that of the earth, it is said to have *positive potential;* if it is below that of the earth it has *negative potential*, and electricity flows from the earth to the object. Two substances, both positive or both negative, but having different degrees of potential, are positive and negative in relation to each other. This is what is known as *relative potential.*

In order to produce large quantities of electricity for medical purposes various *electrical machines* are employed; some of these act by friction and induction, while the more modern forms, as the Tœpler-Holtz, depend upon induction alone.

One of the latest forms of the Tœpler-Holtz machine is shown in Fig. 1. It consists of two thin circular plates of glass, a short distance apart; the larger one is properly supported and fixed; the other, smaller in diameter, turns on a horixontal axle by means of the multiplying wheel and band seen to the right in the figure. The larger or fixed plate is provided with armatures, *i. e.*, gilt paper glued upon the posterior surface, and these as well as the plates are varnished. In front of the movable plate, at the level of the armatures, are two brass combs attached to two brass conductors, supported in front upon condensers, and terminating in large brass knobs through which pass brass rods—dischargers; the latter terminate centrally in small metal knobs, and laterally they are provided with vulcanite handles. Upon the front of the revolving plate are a number of small brass buttons which, when the plate revolves, are touched by the teeth of a brush, arranged so as to connect this surface with the armatures.

To work the machine, the knobs of the discharger are

FIG. 1.

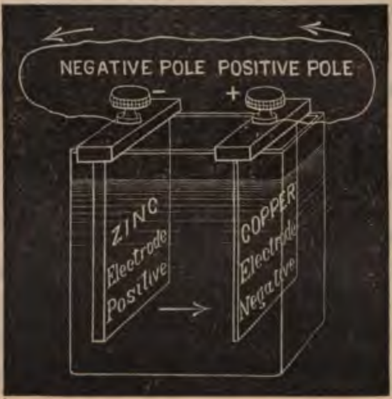


THE NEW UNIVERSAL TŒPLER-HOLTZ MACHINE.

the lower potential, and the equilibrium is restored; but chemical action continuing, the constant current is the result. Such an arrangement constitutes a *galvanic couplet or cell*, and is shown in Fig. 2.

The electricity flows from the plate most acted on (*zinc*) through the liquid to the conducting plate (*carbon*), thence through the connecting wires to the zinc again. Thus, as will be seen, the zinc constitutes the positive plate but negative pole, the carbon forming the negative plate and positive pole. The

FIG. 2.



circuit is said to be "open" when the wires are separated, "closed" when they are in contact.

The property of creating difference of potential, upon which the electrical current depends, is known as *electro-motive force.*

Electric force moves matter. *Electro-motive force* is an imaginary force moving an imaginary fluid electricity; its amount depends entirely upon the nature of a cell, and not at all upon its size.

To secure accuracy of admeasurement "electrical units" are employed; the more important of these are as follows:—

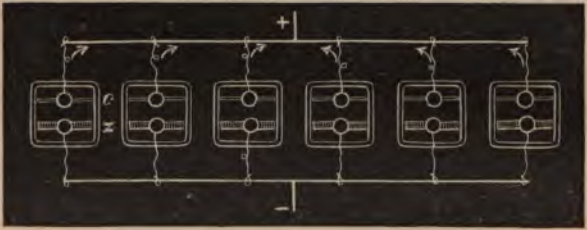
UNIT	SYMBOL.	NAME.
of Quantity,	Q.	Weber.
of Current strength,	C.	Ampere.
of Electro-motive force,	E.	Volt.
of Resistance,	R.	Ohm.

"The use of the term Weber is restricted to the unit of quantity; the Ampere denotes the same quantity, but includes the twin factor implied in the word current."

"The *Volt* is a little less than the electro-motive force of a freshly-charged Daniell's cell."

All the parts in a galvanic circuit offering more or less resistance to the passage of a current, obviously the current strength (C), will be equal to the electro-motive force (E) divided by the resistance (R), or $C = \frac{E}{R}$ (Ohm's law).

FIG. 3.

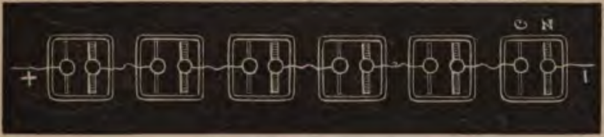


The resistance offered by the wires is inversely proportional to their sectional area and directly to their length; it also varies with the specific conducting power of the metal of which they are composed.

The resistance of the human body, practically that of the epidermis, is very great; it may be diminished by increase in the size of the electrodes, of the amount of pressure made by them, and of the duration of their application; also by increase in the moisture and vascularity of the skin.

By *electric density* is meant the proportion existing between the sectional area of a conductor and the quantity of electricity conveyed by it; the greater the sectional area, the quantity remaining the same, the less the density.

FIG. 4.



Arrangement of Elements.—In the *simple circuit* or *arrangement in surface* all the zinc plates are connected, forming the negative pole, all the carbon plates forming the positive pole. See Fig. 3.

When the carbon of the first cell is connected with the zinc of the second, and so on throughout the series, the first zinc forming the negative and the last carbon the positive pole, we have a *compound circuit* or *arrangement in series*. See Fig. 4.

The cells may also be variously grouped. The arrangement in any particular case will depend upon the amount of resistance to be overcome, and upon the object to be attained. As a general rule, the grouping should be such as to make the internal resistance as nearly as possible equal to the external. For ordinary galvanic application to the human body, whose resistance is very great, the cells are connected in series; whereas, for electrolytic and heating purposes, the arrangement in surface is adopted.

When the current is passed through a portion of the body, a flow of the interstitial fluids occurs from the anode to the kathode; this is known as the *cataphoric action* of galvanism.

Luminous and heating effects may be obtained by causing a strong current to pass through a platinum wire.

Chemical Effects.—Electrolysis is the decomposition of a body,—oxygen and acids collecting at the anode; hydrogen, alkalies, and bases at the kathode.

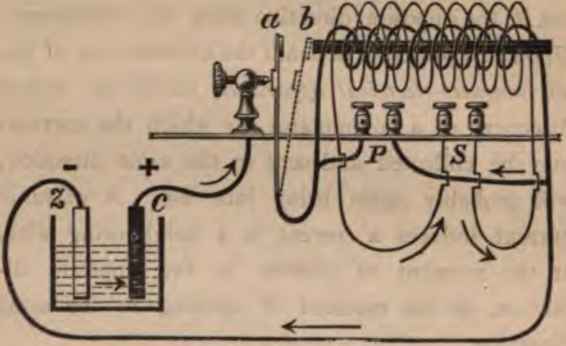
(*b*) Faradism, or Induced Electricity.

"The faradic current is generated by the inductive influence of galvanism or magnetism, in presence of variation in intensity of this influence." An electrical current is developed in a closed coil of wire when a magnet is brought near, and another, but in the opposite direction when it is withdrawn. Upon this principle depends the construction of the old *magneto-electrical apparatus*, which the recent discovery of a commutator, by which the currents may be collected and sent in the same direction, will probably again bring into use. A galvanic current induces a current in a neighboring wire, at the moment of closure in the opposite direction, at the moment of opening in the same direction.

When the current traverses an insulated helix within which is placed a soft iron bar, the bar becomes a magnet on closure of the circuit, to be instantly demagnetized when it is broken. These are the principles involved in the construction of the *electro-magnetic*, the common *faradic battery*. Their application can be clearly understood from Fig. 5.

Z, zinc element; *C*, carbon element; *P*, binding-posts for the primary coil; *S*, binding-posts of the secondary coil; *a*, the interrupter when the circuit is passing to the helix; *b*, the interrupter when the circuit is broken. The screw (shown in contact with *a*) allows of the adjustment of the interrupter to the bundle of soft-iron wires within the primary helix, thus making the interruptions fast or slow at the will of the operator. The patient is connected with the battery in action by means of cords attached to the binding-posts at *P* or *S*. These cords are not

FIG. 5.



(*From Ranney.**)

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* "Practical Suggestions respecting the Varieties of Electric Currents and the Uses of Electricity in Medicine," by Ambrose L. Ranney, M.D.: D. Appleton & Co., 1885.

shown in the diagram, but are shown in Fig. 1. The arrows show the direction of the currents. The zinc is marked as the negative element (—), and the carbon as the positive (+) element of the battery. Note that the wire of the primary coil is represented as coarser than that of the secondary; that the secondary coil has no connection with the elements of the cell; that the current going to the primary binding-posts is generated by the iron core, and is not that which originates in the galvanic cell; and that the interrupter has a small piece of platinum soldered upon it where it comes in contact with the screw, so as to prevent oxidation at that point. Patients feel the current made by the "break" more than that from the "make" of the circuit; hence one electrode apparently gives a stronger current.

The *primary current* is that which results from the inductive action of the coils of the inner helix upon each other, strengthened by the inducing influence of the magnet.

The *secondary current* is that which passes *to and fro* in the outer helix; each electrode is alternately anode and kathode, but the direct current is so much the stronger that it may be alone considered, and this current being understood, we may properly speak of anode and kathode in reference to faradism.

The strength of the induced current is in direct proportion to the number of coils in the outer helix, and to the strength of the exciting galvanic current. It may be increased by withdrawing the metallic cylinder which surrounds the helix, and thus lessens the inductive influence.

The faradic current has no marked chemical nor heating effects; it has not the penetrating power possessed by galvanism.

CHAPTER II.

FORMS OF ELECTRICAL APPARATUS FOR MEDICAL AND SURGICAL USE.

Constant Elements.—In the simple "one-fluid cell" already described, it is found that, practically, the current is not *constant*. The zinc is rapidly dissolved, the fluid becomes saturated with salts, and the hydrogen from the electrolytic decomposition of the water accumulates on the carbon plate, polarizing it, and so preventing the passage of electricity to and through it. All these influences aid in rapidly reducing the current to a minimum.

The destruction of the zinc and the weakening of the current by the formation of numerous small couplets between particles of zinc and the impurities they contain is prevented by amalgamation. Polarization is prevented by having *two fluids* so arranged as to chemically utilize the liberated hydrogen. Cells so constructed are said to be *constant*.

Of single fluid cells, the *Grenet* may be taken as the type; the elements are zinc and carbon immersed in a dilute solution of sulphuric acid, bichromate of potassium being added as a partial depolarizer. This form is often used in faradic batteries.

The *Daniell* is a good example of the "two-fluid element." A glass vessel contains solution of sulphate of copper and a perforated copper cylinder with a rim above; on the rim rest crystals of copper sulphate, which keep the solution saturated. Inside of the copper cylinder is a porous earthenware vessel containing a zinc plate immersed in solution of dilute sulphuric acid. The hydrogen set free by electrolysis decomposes the copper sulphate, forming copper and sulphuric acid, the former being deposited on the copper cylinder, the latter going to reinforce the sulphuric acid already present. Good cells of this type are those of *Siemens* and *Halski*, *Leclanche*, *the chloride of silver*, etc.

For electrolysis, Stöhrer's elements are specially commended by Bartholow.

For luminous and heating effects, we use either large cells or small elements connected in surface. Among the best are *Piffard's* and *Byrnes's*. *Polarization* or *storage cells* are also used for these purposes. "When two plates of platinum are dipped into water and attached to the poles of a battery, they become polarized; that is, the anodic plate becomes covered with bubbles of oxygen, the kathodic with bubbles of hydrogen. If now the plates are connected with the terminals of a galvanometer, it is found that a polarization current is set up from the hydrogen through the liquid to the oxygen (*i. e.*, in the opposite direction to the battery current), and that this polarization current may last a long time if the plates are large enough. This property has been made use of in the construction of Plante's storage cell and Trouvé's Electrical Polyscope.

Accessory Apparatus.—The *Galvanometer* is an instrument used to show the presence, strength and direction of a current of electricity.

The *Rheostat* is so constructed as to allow an accurate gradation of current resistance when it is placed in the circuit.

The *Selector* or *Cell-enumerator* is an arrangement by which any desired number of cells may be at once brought into circuit.

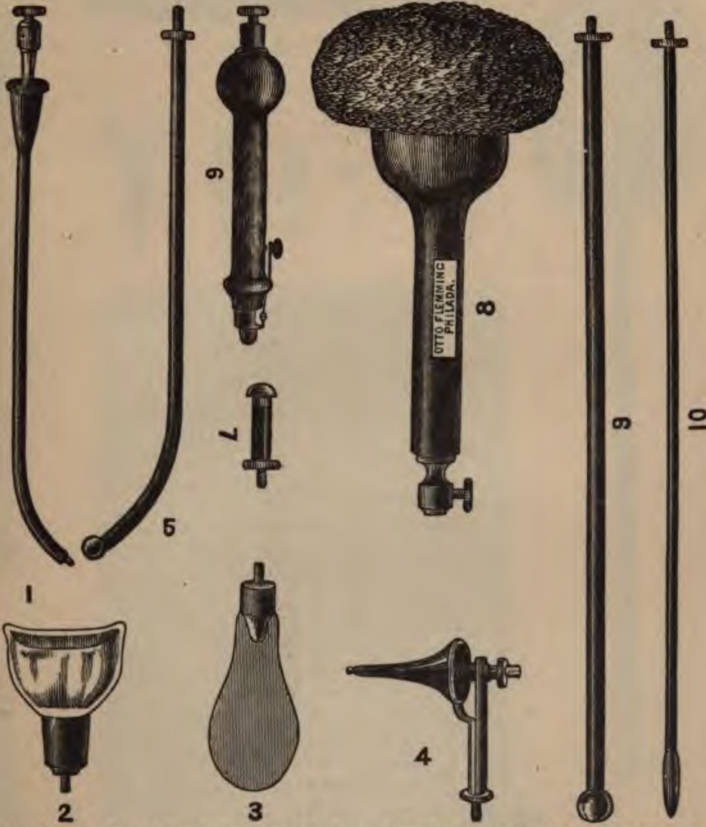
The *Polarity Changer* or *Commutator* affords a means of instantly changing the direction of the current and then reversing the poles.

The *Interrupter* (for the galvanic current) is usually contained in the handle of the electrode; a button is pressed upon, and this by means of a spring makes and breaks the contact.

Electrodes are the direct means of applying electricity to the body; they are of very various forms, as shown on pages 45 and 47.

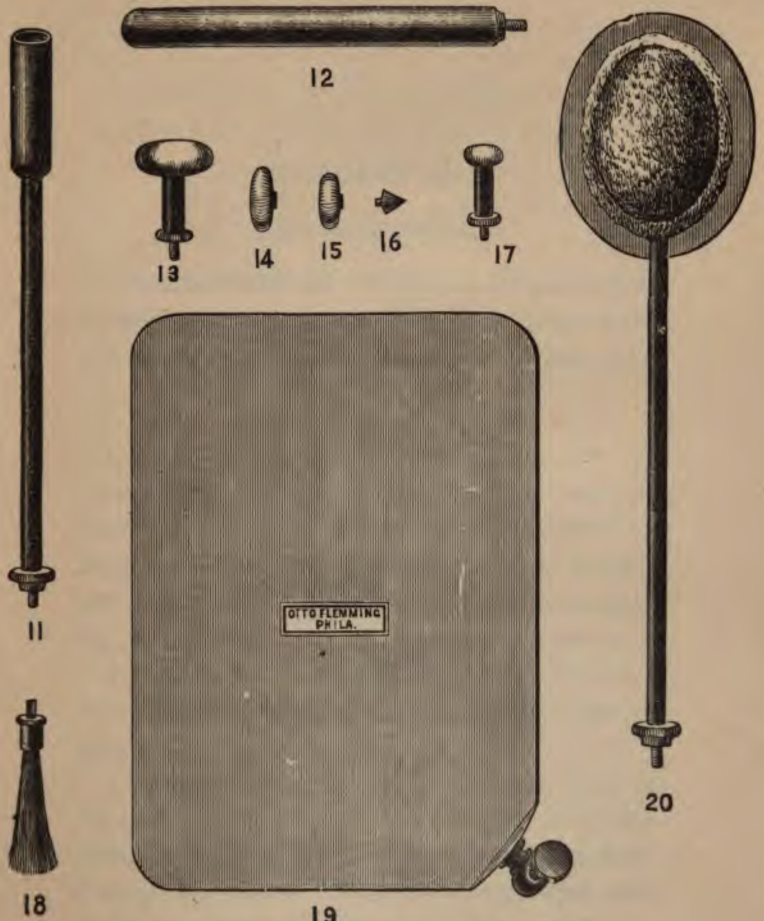
Disks of carbon covered with waste leather are preferable to those of metal covered with sponge.

Rheophores are the wires connecting the electrodes with the battery; they should be of ordinary telegraph wire insulated by a rubber coating.



FORMS OF ELECTRODES USED IN THE VARIOUS KINDS OF ELECTRICAL APPLICATIONS.

1. Laryngeal (Dr. Strawbridge's Eustachian Tube) Electrode.
2. Eye "
3. Tongue "
4. Ear "
5. Nasal "
6. Interrupting Handle Electrode.
7. For Special Nerves "
8. Large Sponge "
9. Uterine and Rectal "
10. Urethral "



11. Cup-shaped, for Mouth of Womb.
12. Vaginal Electrode.
13. Sympathetic Nerve "
14, 15 and 16. Disks, Olives, Points, etc.

17. Carbon Electrode.
18. Wire-brush "
19. Foot-plate "
20. Spinal "

CHAPTER III.

ELECTRO-PHYSIOLOGY.

I. **MAGNETISM.**—Of the physiological effects of magnetism little is definitely known; the north pole seems to cause irritation, the south pole sedation.

II. **STATIC ELECTRICITY.**—1. In the *electric bath* the patient is placed on an insulated stool, is connected with the prime conductor by means of a chain, and is charged, positively or negatively, as desired. The electricity enters and leaves the body painlessly, slight tingling of the surface is experienced, face becomes flushed, hair erect, action of heart accelerated, and in a few moments a general perspiration breaks out.

2. *Electrization by sparks.*—When the body is charged as above, if we bring near a conductor (metallic knob usually), sparks can be withdrawn through the clothes; these are accompanied with burning sensations and the production of wheals.

3. In *electrization by shock*, the part to be acted on is placed in the circuit between the inner and outer coatings of a Leyden jar, when a severe shock is felt.

4. *Motor Effects.*—By a special arrangement of the static machine a so-called "static induction current" is produced; this current has the motor effects of faradism, with the advantage that it is painless.

III. CURRENT ELECTRICITY.

1. *Galvanic excitation of motor, sensory and mixed nerves.*—When a galvanic current of average strength traverses a *motor nerve*, a muscular contraction results only at the moment of making and breaking the circuit, and upon variations in the current strength; the amplitude of the contraction will depend upon the rapidity of the changes, and upon the pole that is placed over the nerve.

Place a large electrode over the sternum or some other indifferent point; then with a small one over a motor nerve or muscle ascertain the minimum current strength necessary to produce a contraction upon closing (C) and opening (O) the circuit, first with the kathode (K), then with the anode (A).

The increase of current strength necessary will be found to occur in a regular order known as the *normal polar formula*, and is as follows:—

1. Weak current	KCC
2. Medium current	ACC AOC
3. Strong current	KOC

The contractions resulting from sudden reversals of polarity by means of the commutator are known as *voltaic alternatives*, and are much more powerful than those resulting from simple makes and breaks.

During closure the excitability of the nerve is diminished at the point of contact with the anode, (*anelectrotonos*), increased at the kathode (*katelectrotonos*), so that excitation of the nerve results from AO., *i.e.*, the return to normal from anelectrotonos, and from KC., *i.e.*, the production of katelectrotonos.

Excitation upon closure really only occurs at the kathode; upon opening only at the anode, KOC and ACC being accounted for on the theory of *virtual electrodes*, which cannot be discussed here. (See De Watteville.)

Nothing is gained by placing both poles over the nerve, for the current proceeds in all directions from the electrode, and at a short distance the nerve is practically devoid of current. This diffusion of the current gives rise to "induced contractions" in neighboring muscles.

Pain results from excitation of a *sensitive nerve*, even when the current flows continuously, and is felt both at the point of application and in its peripheral distribution. In *mixed nerves* the effects are pain and muscular contractions.

2. *Faradic excitation of motor, sensory and mixed nerves.*—When a slowly interrupted faradic current traverses a motor nerve, a muscular contraction occurs at each break, but if the interrupter vibrates rapidly the contraction becomes tetanic. Similar stimulation of a *sensitive nerve* causes pain, and of a *mixed nerve* pain and motion.

The effect of galvanism when applied directly to *muscle* is the same as that resulting from stimulation of its motor nerve, but the short duration currents of faradism do not so readily affect it; indeed, the contractions from faradism are probably due to stimulation of the intra-muscular nerve elements. The reactions to both currents are more powerful by *direct stimulation*, in which the electrode is placed over the point of entrance of the motor nerve into the muscle (*motor point*);* but in the case of large muscles with several motor points the whole muscle is best thrown into contraction by *indirect stimulation*—the electrode being over the nerve itself. A healthy muscular contraction is abrupt and sudden in its rise and fall.

Non-striated muscle reacts to both currents in its normal vermicular manner. The *heart muscle* does not react to the direct application of faradism, but does to galvanism; its rhythm may be increased or diminished by corresponding interruptions of the galvanic current. Percutaneous electrization of the *brain*, from before backward, causes a sickly sensation of cérebral disturbance; from side to side induces nausea and vertigo. Faradic currents do not affect the brain.

Although it is established that the *spinal cord* is penetrated by electrical currents, yet the effects produced are confounded with those resulting from the inevitable stimulation of the nerve roots, and cannot be distinguished.

It is still a disputed point whether the *cervical sym-*

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* See pages 92, 93.

pathetic can be influenced by electrical currents in the living subject.

A strong current passed through the *pneumogastric nerve* arrests the heart in diastole, and the respiratory movements during inspiration; a weak current increases the frequency of the heart's action.

Faradization of the pneumogastric causes vomiting and arrest of intestinal peristalsis; quiescence of the stomach is induced by galvanism.

Galvanization of the *eye* causes flashes of light upon current opening and closure, KC and AO producing one set of colors, and KO and AC another different set.

Subjective noises from electrization of the *ear* occur only on KC and AO. A current passing through the *tongue* causes the "galvanic taste;" through the *nose*, subjective odors.

All the abdominal organs containing muscular fibre may be acted on by percutaneous electrization.

CHAPTER IV.

ELECTRO-DIAGNOSIS.

In certain diseases of the nervous system the neuromuscular apparatus does not respond in the usual manner; the normal polar formula is altered. Upon examination we may find:—

I. **Normal Reactions.**—These indicate a healthy condition of the anterior spinal cornua and of the nerves arising from them, notwithstanding the part affected may be the seat of spasm or paralysis.

They occur 1. In all cerebral diseases unaccompanied by secondary changes in the cord.

2. In spinal diseases of the white matter only, at least in the early stages.

3. In circumscribed transverse spinal lesions in parts below, though degenerative reaction (De R) will be present in organs supplied directly by the seat of lesion.

4. In mild affections of peripheral nerves from cold or pressure.

II. Quantitative Changes.

1. *Excitability augmented.* — In early stages of cerebral hemorrhages, locomotor ataxia, facial paralysis, etc., and in tetanilla. Also occur in first stage of De R.

2. *Diminished excitability* accompanies De R in some of its phases; occurs, also, in old cerebral paralyses with secondary degeneration, old leuco-myelitic diseases, certain cases of progressive muscular atrophy and pseudo-hypertrophy, in simple muscular atrophy from disuse, wasting diseases, and joint affections. Its occurrence excludes poliomyelitis, hysteria, purely cerebral disturbances, and shamming.

III. Quantitative and Qualitative (Serial and Modal) Changes: Reaction of Degeneration.

1. *Alterations in nerve reactions.*—A more or less rapid diminution, ending usually in loss of reaction equally to both currents. The duration of this period varies, but excitability usually reappears about the time that the nerve becomes capable of transmitting motor impulses.

Qualitative changes are rare.

2. *Alterations in muscle reactions.*—The changes in the reactions to faradism pursue exactly the same course as in the nerves, and are due to the degeneration of the intra-muscular nerve elements.

The galvanic reactions are characteristic :—

(*a*) QUANTITATIVE CHANGES.—A temporary diminution is followed by a rapid increase of excitability, reaching its maximum in the second week, and then gradually falling to or below normal.

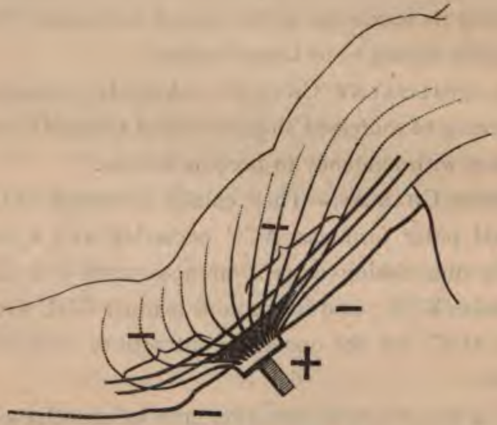
(*b*) QUALITATIVE CHANGES.—A modal alteration consisting of increased sluggishness of muscular contraction with tendency to become tetanic.

SERIAL CHANGES.—These consist in reversal of the normal polar formulas, ACC occurring with a constantly diminishing current strength until it finally overtakes KCC; and in the same manner KOC overtakes AOC, but the opening contractions soon disappear.

De R may still be present after months have elapsed, and may persist after motility is restored, if this has been lost.

The presence of De R means a specific "degeneration atrophy" of the neuro-muscular apparatus, due to a cutting off of the trophic influence of the anterior spinal cornua, from disease of these cornuas, or of the nerves proceeding from them. It is not inconsistent with the preservation of motility; is present in anterior poliomyelitis, lead paralysis and severe cases of paralysis from peripheral nerve lesions.

FIG. 6.



This diagram represents the points of entrance and exit of the current in a nerve submitted to percutaneous excitation with one electrode, and the consequent formation in it of two zones of opposite electrical character; anodic and kathodic. The anode is supposed to lie over the ulnar nerve, whilst the kathode rests on the trunk. The polar anodic zone is shaded. The two brackets show that, owing to the diffusion of current, the unipolar excitation of the imbedded nerve sets up in it a descending as well as an ascending current. The signs — indicate that under such circumstances the electrotonic condition of the nerve in the neighborhood of the electrode may be found the opposite of that set up immediately under the electrode.

In partial De R the galvano-muscular reactions are the same as in the complete form, but the farado-muscular and the galvano-nervous and farado-nervous reactions are normal or slightly diminished ; here the trophic influence is in some unknown manner cut off from the muscles, but not from the nerves. It occurs in amyotrophic lateral sclerosis (not always), progressive muscular atrophy (of central origin), bulbar paralysis, mild acute poliomyelitis, and in mild forms of peripheral paralysis.

IV. **Changes in sensation.**—Electro-diagnosis only enables us to ascertain the presence, location, and degree of hyperæsthesia and anæsthesia.

V. **Special senses.**—We have as yet no certain data in the diagnosis of the diseases of the *organs of vision.*

Of *taste,* we can only judge whether it be present or absent.

The presence of galvanic hyperexcitability of the *acoustic sense* affords an indication for treatment in certain cases where the hyperexcitability is accompanied by subjective noises; upon KC these noises often disappear at once and completely.

PRACTICE OF ELECTRO-DIAGNOSIS.

The patient is so placed that symmetrical parts are in the same position and equally relaxed. A large, well-moistened electrode is fixed over the sternum, and a smaller one with interrupting handle used as the exciting electrode. Comparison of symmetrical parts is best, but if the disease be bilateral, some other part, the condition of whose reactions is known, must be selected. First, with a current of ten cells, having a galvanometer in circuit, ascertain the amount of deflection when the electrode is placed over each point to be tested; by this means we may eliminate the error arising from difference in tissue resistance. Mark the points tested so that the electrode may be placed exactly over them, and see that the duration of closure and opening is exactly the same on the two sides. Now, with a slowly interrupted faradic current, note the amount of withdrawal of the cylinder at which the first contraction occurs, and also the maximal contraction with very strong currents.

Next, with the galvanic current, ascertain the minimum number of cells with which a contraction occurs upon KC, AC, AO and KO, in the order given; also note the manner of the contraction.

A bifurcated rheophore may be usefully employed in these experiments, enabling us to compare reactions on different sides of the body at the same time and with the same current.

In testing *sensation*, the skin should be dry and dusted with some drying powder; the wire brush or Erb's electrode may be employed.

In examination of the *eye*, the active electrode is placed over that organ; of the *ear*, in front of the tragus or introduced into the ear, which has previously been filled with water. The *sense of taste* is tested by placing a small kathode over tongue, etc. Various electrical explorers have been invented for the purpose of detecting the presence of metallic foreign bodies in the body, but so far they have not been satisfactory.

CHAPTER V.

ELECTRO-THERAPEUTICS.

I. **Magnetism.**—There is much difference of opinion both as to the curative power of magnetism and as to the manner in which it should be applied. The most remarkable cures have been obtained in those cases where the symptoms were subjective, and the influence of psychical impressions could not be eliminated,—viz., in the various manifestations of *hysteria*, in *neuralgia*, *anæsthesia*, and *chorea*. In neuralgia the south pole is stroked over the seat of pain or held upon it; in the other affections named, a variable number of horseshoe magnets are bound upon the parts for a variable length of time.

Both permanent and electro-magnets are also successfully used for the *extraction of bits of metal from the interior of the eye*, a magnetized needle being passed into the neighborhood of the foreign body.

II. **Static Electricity.**—The static induced current may be advantageously substituted for the faradic in case of *paralysis;* also in muscular contraction, such as occurs in *torticollis, histrionic spasm,* etc.; here a weak, rapidly interrupted current often affords great relief.

Remarkable cures are effected in *anæsthesia, hyperæsthesia* and *neuralgia* by insulation and the withdrawal of sparks from the affected parts.

Hysteria is particularly amenable to Franklinism. Cases of *hystero-epilepsy* are reported as cured by it.

Good results are obtained in *chorea* by insulation and sparks.

In *muscular rheumatism,* and in *stiff joints* from *chronic rheumatism and gout,* sparks are withdrawn from the affected parts, with marked relief in many cases.

By withdrawal of sparks from the various organs of the body, tonic and invigorating effects are obtained in cases of *neurasthenia, exhaustion,* and *debility* from various causes.

Torpid liver, gastralgia, dyspepsia, and *constipation* have been relieved by drawing sparks from over the affected organs, the action being reflex, or, as asserted by some, directly upon the organ.

III. **Dynamic Electricity.**—1. *General remarks.* The only accurate knowledge we possess of the physiological effects of electricity concerns its stimulating and modifying action on nerve and muscle; obviously these are insufficient to account for therapeutic results, but another very powerful factor is its so-called "*catalytic action*" embracing:—

(*a*) Electrolytic and cataphoric effects. (*b*) Stimulation of the flow of blood and lymph, directly by excitation of the vessels, indirectly by excitation of the vaso-motor nerves. (*c*) Stimulation of the trophic tracts and centres.

These effects are those of galvanism; the faradic current is markedly stimulating, slightly modifying, and its catalytic action, if it exist at all, is very slight. You will be guided in the selection of the proper current in individual cases by these considerations. As a general rule, the faradic current is best for stimulation and the galvanic for sedation, but to excite contraction in degenerating muscle the galvanic current is vastly superior.

There are two chief modes of applying electricity therapeutically—the *polar* and *directional* methods. For a discussion of the merits of each, the reader is referred to De Watteville, whose conclusions are adopted here, viz., that no peculiar effects result from the direction *per se*, but that this method may sometimes be employed as a matter of convenience on purely physical grounds. For the production of electrotonic effects the polar method only can be used, the anode being the sedative and the kathode the stimulant pole. The polar method is usually employed in other cases also, because it affords the best means of reaching the affected part with a current of maximum density.

This consideration will also guide us in the choice of size and position of electrodes. No matter where the points of application, the current diffuses itself throughout the entire body, but it will be strongest where it has greatest density, *i. e.*, under the smaller electrode.

For a small point not deeply placed, *e. g.*, a motor point or an individual nerve, place a small electrode over the spot and a larger one at a considerable distance. For a large part (*e. g.*, deltoid muscle) similarly placed, use moderate-sized electrodes closely approximated; for a large joint or a deeply-seated part, as the brain or bladder, large electrodes placed on opposite sides, so that the part to be affected is in the straight line between them; for an elongated organ like the spinal cord, large electrodes over the part, but as widely separated as possible.

In dosage we must take into consideration the part to be affected, the size of the electrodes, the resistance of the part, and the absolute current strength as indicated by the galvanometer.

Always first try the effect of the current upon yourself, on the cheek, or, in case of weak currents, upon the tongue.

Avoid unnecessary pain by a gradual increase of strength, and by firm and uniform pressure on the electrodes. In nervous affections, applications should be made to the seat of disease as well as to the seat of symptoms; the peripheral treatment, besides its local action, often reflexly affects favorably the central lesion.

In central applications we desire catalytic effects chiefly, and hence employ galvanism only.

In conditions of generally impaired nutrition, and in constitutional disease, one of the methods of *general electrization* is employed.

Electrization of one part should not continue longer than two (2) minutes, and an entire sitting not more than ten (10) to fifteen (15) minutes. Sittings should occur not oftener than once daily, and in chronic cases two or three times a week will suffice. We should be guided, however, by the duration of the effects produced.

2. Methods of Electrization.

(*a*) *Localized galvanization.*—To obtain the sedative effect alone, the electrode should be stationary (*stabile*), and the current uniform or gradually increasing; by sponging over the part with an electrode, without, however, breaking the contact (*labile method*), we get catalysis combined with muscular contraction. For purposes of stimulation, the current should be interrupted.

(*b*) *Localized faradization.*—If a whole limb has to be faradized, the labile method may be resorted to, the motor points being sought for when individual muscles are to be treated, the motor nerve where the muscles cannot be reached directly.

In faradization of the skin, when employed for its reflex effects, the current should not be strong enough to excite muscular contraction.

(*c*) *General faradization.*—In this method the entire body is subjected to the influence of faradism. The patient is seated in a chair, with the feet resting on a metallic plate, which constitutes the kathode; the operator, taking the anode in his left hand, passes his well-moistened right hand with firm pressure from the forehead over the head to the occiput, and then over the anterior portion of the neck; now, the hand being substituted by the electrode, this is sponged over the trunk and limbs, the entire sitting lasting 15–20 minutes. This method seems to be very serviceable in the treatment of constitutional diseases, the neuroses, and all affections in which general debility, muscular or nervous, forms a prominent feature.

(*d*) *General galvanization* is too powerful ever to be required, except in a few rare cases which prove insusceptible to the preceding method.

(*e*) *Central galvanization.*—According to Rockwell, this method is most useful in those neuroses, such as hysteria, chorea, etc., when muscular and nutritive changes are not well marked. The kathode is held over the epigastrium and the anode passed over the head from vertex to occiput, thence along the anterior edge of the sterno-mastoid muscle to the clavicle, and again from the occiput along the whole length of the spine, thus bringing the entire nervous system, cerebro-spinal and sympathetic, under the influence of the current.

(*f*) *Electric bath* (*galvanic or faradic*).—The electrodes are placed in the water contained in a tub of some non-conducting material, or one electrode is placed in the water and the other is connected with a large sponge, with which the patient sponges his entire body. This method is only useful in general diseases.

(*g*) *Subaural galvanization.*—This term has been applied by De Watteville to a method of treatment in which the kathode is placed just beneath the ear, and the anode over the lower cervical and upper dorsal vertebræ, a current of 5–10 cells being passed for 3–4 minutes on one or both sides. Good results have been obtained from this practice in very various affections. The effects produced were formerly supposed to be due to stimulation of the cervical sympathetic; but though this may be a factor, the simultaneous excitation of the spinal cord, medulla, pneumogastric, etc., must be taken into consideration.

(*h*) *Galvano faradization.*—In this method the batteries are so arranged that the two currents may be utilized at the same time and through the same electrodes. It economizes time when both currents are indicated, prevents the fatigue which may result from the ordinary faradic stimulation of muscle, and may prove useful in other ways.

3. Special Therapeutics.

(*a*) **Paralysis.**—The modifying, stimulating and catalytic effects of the current being exerted directly upon the part to which it is applied, and its stimulant influence by reflex action upon the centre presiding over this part, it is evident that, to obtain the best results, the treatment must be "in loco morbi" as well as "in loco symptomatis." The seat of lesion should be galvanized by a weak current, stabile if central, stabile or labile if peripheral. The obstacle to conduction is best overcome by interrupted kathodic galvanization above the seat of lesion, or, if this be not possible, by faradization of the sensory end of the reflex arc containing the lesion. Faradization and interrupted kathodic galvanization are to be used upon the nerves and muscles, the seat of symptoms; finally, faradization of the skin is to be employed for its reflex nervous and vaso-motor effects on the centre.

(*b*) **Spasm and Cramp.**—This class of affections is not so much benefited by electrization as are the paralyses. The indications are to obtain the sedative effects of the current by anodic galvanization of the seat of lesion, and of the peripheral motor nerve; to induce exhaustion of the neuro-muscular apparatus by over-excitation, by means of powerful interrupted kathodic galvanization, or faradic currents of increasing strength ("swelling faradic currents"); to act upon painful and pressure points by weak anodic galvanization; to stimulate the antagonist muscles. These various means to be tried successively in individual cases.

Facial spasm, when recent, may often be relieved by galvanization. De Watteville employs for this purpose a large anode placed over the lower part of the ascending frontal and parietal convolutions on the opposite side, a weak stabile current being passed for 5 minutes; failing in this, the various methods described for spasm in general should be tried. The more localized affections, *blepharospasm* and *nys-*

tagmus, are treated on the same principles. *Trismus*, when of peripheral origin, may be relieved by weak stabile anodic galvanization. When rheumatic in character, *torticollis* often yields readily to swelling faradic currents or to stabile galvanization of the affected muscles; but in old cases, and in those of central origin, all methods of electrization fail.

Cutaneous faradization of the epigastrium is recommended by Erb in *singultus*, *sneezing*, and other *respiratory neuroses*.

(*c*) **Anæsthesia.**—The principles of treatment are much the same as in the paralyses. Our chief objects will be to overcome the obstacles to sensory conduction, and to increase the excitability of the sensory receptive organs, central and peripheral, employing for these purposes peripheral cutaneous faradization, and labile kathodic galvanization, the anode resting on the point of origin of the nerves. It has been found that faradization of a small part of the anæsthetic area will often effect a cure of the whole, and may even relieve special sense anæsthesia.

(*d*) **Hyperæsthesia.** *Pain. Neuralgia.*—Electrization effects remarkable cures in cases of localized pain, especially in that form known as neuralgia. It is in idiopathic neuralgia, and in the gouty, rheumatic and neurotic forms that the best results are obtained. First, we fulfill, if possible, the causal indication by treating the disease of the brain, cord or nerves, or the constitutional condition, by the methods to be described later on; next we treat the finer nutrititive change, the so-called neuralgic change upon which the pain directly depends. A weak galvanic current is passed through the nerve, the anode being over the seat of pain, or both poles may be over the nerve. Faradic currents, employed in the same manner, are sometimes successful, and counter-irritation with the faradic brush is often useful. Painful and pressure points must be treated in the manner already indicated.

Trigeminal neuralgia being often due to deep-seated organic changes, the results of treatment are usually only palliative. A galvanic current (5–10 cells) is employed; anode being over point of emergence of nerve from the skull, kathode over nape of neck; this may be repeated two or three times daily. To affect the deeper parts of the nerve, transverse conduction through the mastoid processes may be used.

Galvanism, the anode being over points of emergence, is efficient in the treatment of *cervico-occipital neuralgia.*

The *cervico-brachial* form usually yields readily to stabile, or, when associated with paralytic symptoms, to labile galvanization, anode above the clavicle, kathode over the periphery.

Intercostal neuralgia, especially that form associated with herpes zoster, is very rebellious to treatment. Strong currents (30–40 cells) are to be employed, anode near spine, kathode over periphery.

Mastodynia requires the same treatment. Excellent results are usually obtained from electrization in *sciatica.* Strong currents (30–40 cells), a large anode over sciatic foramen; kathode being moved over periphery; or one electrode may be placed in rectum; or electro-puncture may be employed. *Neuralgia* of the *lumbar plexus* is treated on the same principle.

(*e*) **Diseases of the Brain.**—The forms of brain disease which we can hope to affect favorably by electrical treatment are *functional disorders,* by removing the finer nutritive changes upon which they depend; *disorders of circulation,* by the vaso-motor effects of the current; *cerebral hemorrhage* and *softening from thrombosis and embolism*, by removal of circulatory disturbances, restoration of the function of neighboring parts lost from inhibition or sympathy, and improved nutrition of the affected and surrounding parts; *inflammatory and degenerative* changes by improving nutrition and circulation.

We treat the brain directly by cerebral galvanization; indirectly by subaural galvanization; reflexly by faradization of the skin. In applications to the brain use large, well-fitting electrodes, weak currents (2–10 cells) gradually increased and diminished and without breaks, sittings of from one to three minutes. Longitudinal galvanization — anode over occiput, kathode over forehead—is said to increase the cerebral circulation and the reverse position of the electrodes to diminish it.

Electrical treatment of *hemiplegia* from *cerebral hemorrhage,* and from *thrombosis or embolism*, should not be begun until about four weeks after the date of attack. Galvanization of the brain so as to include the seat of lesion should then be cautiously used, the paralytic symptoms, at the same time, being treated in the manner already indicated. If, after a week or ten days, no improvement is manifest, farther treatment is useless; and the same may be said when improvement has begun, but ceases after a few days. The supervention of "late rigidity" also renders the prognosis of improvement unfavorable.

Aphasia is treated on the same principles.

In *monoplegia* and *monospasm* of cortical origin, the affected convolutions are subjected to galvanism, appropriate treatment being instituted for the symptom.

Headache and *insomnia*, when due to *cerebral anæmia*, are relieved by mild, unipolar galvanization, the electrode (anode or kathode, according to individual susceptibility), being slowly passed over all parts of the head; also by general faradization. The same affections, when a symptom of *cerebral hyperæmia*, are to be treated by longitudinal galvanization, kathode on occiput, anode on forehead; and by general cutaneous faradization.

In the *impaired memory*, *confusion of mind*, *vertigo*, *hypochondriasis*, etc., the result of *imperfect nutrition* from *atheroma of the cerebral vessels*, Bartholow has obtained excellent results from a transverse transmission of the current through the brain.

In *bulbar paralysis*, besides central treatment, applications should be made to lips, palate and tongue, and to the side of the neck, in order to stimulate movements of deglutition.

In the treatment of the various *psychoses* some good results have been obtained, especially in the incipient stages, and in cases not due to organic change. In these mild cases longitudinal conduction through the brain is employed, together with general faradization if anæmia and impaired nutrition be coexistent. In cases with *torpor* and *apathy*, cutaneous faradization is useful. General hyperæsthesia, and especially psychical hyperæsthesia, is a contraindication to the use of electricity in these disorders.

(*f*) **Diseases of the Spinal Cord.**—Improvement is to be looked for in the same class of cases as in diseases of the brain; we have here, however, no physiological data upon which to base our treatment; this may be: 1st, direct, if the disease be localized, one electrode over the seat of lesion, the other at an opposite point; if it involves the whole length of the cord, one electrode stationary over either end, the other slowly moved up and down over the spine.

2d. Indirect. General faradization, and cutaneous faradization over the cord or over distant parts. Anodal galvanization of pressure points. Very large electrodes; sittings, three to five minutes, weak currents (8–10 cells) gradually increased to 40–50 cells in some cases.

Excellent results have been obtained in *chronic myelitis* and in *acute myelitis* after the subsidence of the active symptoms. The "direct treatment" described above is to be used, and the paralyses treated on general principles. If there be *paralysis of the bladder* or *rectum*, faradization is to be employed,—one pole over the sacrum, the other in the shape of a special electrode introduced into the affected organ.

In *multiple sclerosis*, *lateral sclerosis* and *posterior spinal sclerosis* (*locomotor ataxia*), galvanization of the cord, and in the case of the first-named affection galvanization of the brain, is to be employed. The treatment must be long continued. Excellent results in locomotor ataxia have recently been claimed for cutaneous faradization over spine and limbs for several minutes daily.

In *acute anterior poliomyelitis* electrical treatment is to be instituted as soon as the fever subsides, galvanization stabile with anode over seat of lesion, and labile to the affected muscles.

This method of treatment proves still more efficient in *subacute and chronic anterior poliomyelitis.* In *pseudo-hypertrophic paralysis* and in *progressive muscular atrophy* the same methods are to be employed, though in these instances with very little hopes of improvement.

Electricity exerts a very favorable influence in *acute ascending paralysis* during the stage of convalescence.

Hemorrhage into the spinal cord and meningeal apoplexy, after the symptoms have become chronic, are to be treated in the same manner as the corresponding affections of the brain.

Chronic meningitis is benefited by stabile galvanization of the entire length of the cord.

(*g*) **Functional Cerebro-spinal Diseases.**—These affections are not so amenable to treatment as at first sight they would seem to be; being of a general character, the more general methods of treatment are specially indicated. In *neurasthenia, spinal irritation* and *railway spine,* very mild ascending galvanic currents are to be applied to the cord, together with galvanization of the brain in cases with cerebral symptoms. Cutaneous faradization over spine, and general faradization are also very useful. Tender points are to be treated in the usual manner.

Hypochondriasis is often improved by general faradization combined with galvano-faradization of the abdomen.

The cures in *hysteria* are not so large as might à priori have been expected. Begin with weak currents very cautiously applied; central and peripheral applications.

In *essential epilepsy*, *chorea minor*, and *chorea major*, good results have been obtained from galvanization of the brain, in conjunction with subaural galvanization and general faradization.

Writers' cramp, and a similar affection in pianists, telegraphists, etc., may in its earlier stages be relieved by electrical treatment, aided by rest and massage. In the spastic cases stabile or labile galvanic applications to the affected parts, anode being over brachial plexus; in the paretic form faradization proves more useful. Cases of *tetanus* have been reported as cured by electrization. Mild stabile galvanic currents with polar applications of anode over spine, and over sensory nerves and skin of extremities; stabile descending currents to cord.

Tetany is treated in the same manner with favorable results; faradization of the spine and peripheral motor nerves may also be employed in this affection. The faradic brush is used in *catalepsy* to arouse the patient from his trance.

Not much good is accomplished by the electrical treatment of *tremor*, per se; the stimulant and invigorating applications of the current are those indicated.

The electric bath is sometimes useful in *mercurial and lead tremors*. *Paralysis agitans* is not benefited by electricity.

Marked improvement and even cures have been reported from the use of galvanism in *Basedow's disease;* galvanization of the pneumogastric and brain, and subaural galvanization are the methods employed.

In cases of *migraine* the galvanic current should be passed daily during the interval from nape of neck to epigastrium, and through the head; during the attack applications to the head of the "faradic hand" are extremely useful.

Diabetes, *insipidus* and *mellitus* are treated by central galvanization; in the first, cures have been reported, but in the last the results have been chiefly negative.

(*h*) **Diseases of the Peripheral Nerves.**—The results of treatment will necessarily depend upon the form of disease—traumatism, neuritis, degenerative changes, etc. The catalytic, modifying and stimulating effects of the current are those desired, and to obtain them galvanism is chiefly employed; applications above, below and at the site of lesion.

In paralyses of the *oculomotor*, *trochlear* and *abducens*, the affected muscles are to be galvanized, anode being over nape of neck, and kathode gently stroked over closed eyelid; 6–12 cells. Also stabile galvanization of seat of lesion.

The presence of De R in affections of the *facial nerve* indicates a severe lesion, and recovery, if it occurs at all, will be only after several months. The mild cases usually get well in a few weeks. Labile kathodic galvanization of the affected nerve, and muscles supplied by it, anode being over auriculo-maxillary fossa. Faradization in the same manner is also useful.

Paralyses of *laryngeal nerves* are treated by percutaneous galvanization, anode over nape of neck, kathode stroked over sides of larynx and trachea; also by direct applications to laryngeal muscles.

Phrenic nerves—Artificial respiration.—To induce artificial respiration a strong faradic current is made for one or two seconds, and broken for same length of time. A bifurcated rheophore is employed; the kathode being placed just behind the edge of the sterno-mastoid muscle on both sides, a large anode over lower end of sternum. During passage of the current the arms and trunk are fixed, and during the interval expiration is assisted by pressure on the chest.

Nerves of the upper extremity.—In many cases applications may be made above the seat of lesion by placing one electrode in the supra-clavicular fossa, over the lower cervical vertebræ, or in the axilla. The treatment of the muscular paralysis presents no unusual features. Currents of 15–25 cells should be employed.

Nerves of lower extremity.—Here proximal excitation is not so readily attained; current must be strong and electrodes large; one placed over lumbar region or introduced into rectum; in other respects treatment is the same as for the upper extremity.

(*i*) **Toxic Paralyses.**—In *drop wrist* the most frequent form of *lead paralysis*, labile kathodic galvanization of the affected muscles is employed, anode being over lower cervical vertebræ. The various forms of *diphtheritic paralysis* are treated on general principles.

(*j*) **Diseases of the Organs of Special Sense.**—*Eye.*—In applications to the eye a small concave electrode should be employed; weak currents, 4–8 cells, for five to ten minutes daily. Stabile galvanization with anode, or, in more chronic cases, kathode over the closed eyelid, the indifferent electrode being over cervical vertebræ. Subaural galvanization is also useful. Some good results from these methods have been obtained in *retinitis pigmentosa*, and to a still more marked degree in *inflammatory atrophy of the optic nerve*, but in the primary form of optic atrophy improvement is exceptional. Faradization of the affected part, with or without the brush, is sometimes useful in *chronic conjunctivitis and keratitis.*

It is chiefly nervous affections of the *ear* that are benefited by electricity. In cases of *tinnitus*, that electrode (usually the anode) under whose influence the noises diminish, is placed in front of the tragus, the other being at an indifferent point; the strength of the current should be great enough to check the tinnitus without producing too much dizziness; should last about ten minutes, and should be very gradually diminished to zero, this gradual diminution being very important.

In cases of *deafness*, the electrodes are employed in the same way, but interruptions and voltaic alternatives are made.

(*k*) **Diseases of Muscles and Joints.**—*Simple muscular atrophy* from disuse, joint diseases, etc., is relieved by daily galvanic and faradic stimulation; care being taken not to induce exhaustion. *Weakness and stiffness of joints and muscles from injury* may be removed by the same treatment.

Sprains in the acute stage are much benefited by weak currents through the affected joint; when more chronic, by stronger galvanic and faradic currents, as well to the surrounding muscles as to the joint.

Excellent results are attained in the treatment of *muscular rheumatism*, especially in that form known as *lumbago*. The methods of treatment are the faradic brush, faradization of the muscles with strong currents, and stabile galvanization, with a few voltaic alternatives toward the close of the sitting.

Acute inflammations of the joints are benefited by passing a stabile galvanic current through the affected part, together with labile galvanization of the neighboring muscles. Faradization may be used in the same manner. Authorities are not agreed as to the utility of electricity in the rheumatic form of acute inflammation.

Chronic articular rheumatism is treated in the same manner as muscular rheumatism, with the addition of the use of the galvanic brush, so as to produce small eschars over the affected joint. Arthritis deformans is treated in the same manner, but the results are at best only palliative. Subaural galvanization should also be tried in this affection.

In *chronic gout* temporary relief of the pain may be obtained from local galvanization or faradization.

(*l*) **Diseases of the Heart and Lungs.**—Various methods of electrical treatment are employed with benefit in *nervous asthma*. De Watteville uses galvano-faradization, one electrode over occiput, the other moved on each side from the subaural position to the sternum; sittings, five to ten minutes.

Good results have been attained in *Angina pectoris* during the attack by strong cutaneous faradization of the præcordial region; also by galvanization, anode over præcordia, kathode moved from subaural position over cervical and upper dorsal region. This latter method, the position of the electrodes being reversed, is also useful in *nervous palpitation.* Weak currents and short sittings.

(*m*) **Diseases of the Abdominal Organs.**—Here, in accordance with physical principles, we must employ very large electrodes and strong currents. To reach the stomach a wire may be introduced through the stomach-tube, but usually the percutaneous application will suffice.

In *nervous vomiting* benefit is obtained from galvanization of the pneumogastrics and stomach; a large electrode being over epigastrium and the other applied successively to occiput and sides of neck, two to three minutes in each position.

Dyspepsia is treated by faradization of the stomach from before backward, and from side to side, and by galvanization, from before backward.

Gastralgia, enteralgia, hepatalgia, etc., are benefited by the stabile galvanic current passed from before backward.

In *gastrectasia* the anode is held over dorsal vertebræ, while the kathode is moved over epigastrium; frequent interruptions and voltaic alteratives.

Flatulence is treated on the same principle.

Chronic constipation may often be cured by galvanization or galvano-faradization of the abdomen; one pole over lumbar region, the other moved over course of colon and in a circle around umbilicus; strong currents, frequent interruptions, daily sittings. Faradization may be employed alone, but if so, one electrode should be introduced into rectum. The same plan of treatment is sometimes successful in *intestinal obstruction;* in this case applications may be made several times daily.

In *congestion of the portal circulation* galvano-faradization of the abdomen is useful; it also promotes the absorption of fluid in cases of *ascites;* rapid diminution and even disappearance of the effusion sometimes occurs under its use.

(*n*) **Diseases of the Genito-urinary Organs.** —In affections of the bladder applications may be external, one electrode pressed down over symphysis, the other over sacrum for the detrusor muscle, over perineum for sphincter; or they may be internal, one electrode above symphysis, the other, a urethral electrode, introduced into the bladder, previously partially filled with water.

External stabile applications suffice in *spasm of the bladder;* anode over seat of spasm. *Paralysis of the bladder* should be treated by both internal and external applications; faradization and interrupted galvanization, the latter current being weak, and of short duration. This plan of treatment is also very efficient in *enuresis nocturna.*

In *functional spermatorrhœa and impotence* a large plate electrode is fixed over lumbar region, while the kathode is stroked over perineum, groins and genitals. Galvanization or galvano-faradization with strong currents and voltaic alternatives; if the symptoms be irritative, weaker stabile currents should be used. The vesiculæ seminales may be reached through the rectum, and the orifices of their ducts by a urethral electrode.

Electrization often proves very useful in *amenorrhœa;* a large electrode being fixed over the lumbar region, the kathode is introduced into uterus or pressed down above pubis; weak galvanic currents. The same method is useful in *dysmenorrhœa*, the anode being near the intra-uterine electrode.

In *menorrhagia and metrorrhagia*, in *chronic metritis* and in *displacements*, faradism so employed as to act on the uterine muscular tissue has been claimed to be advantageous.

Inertia uteri during labor and *hemorrhage* occurring at this time may be overcome by the same method; kathode being against cervix, anode over lumbar region.

Recently several cases of *tubal pregnancy* have been reported, in which a transference to the uterus was secured by the action of a galvanic or a faradic current.

The various *pelvic neuralgiæ* are benefited by galvanism, kathode over hypogastrium, anode labile over lumbar region; weak currents gradually increased; a few voltaic alternatives.

The secretion of milk may be much stimulated by faradization of the breasts with strong currents; sittings, ten to fifteen minutes, and frequently repeated.

(*o*) **Diseases of the Skin.**—As the neurotic origin of many skin diseases is being recognized, their treatment by electricity is coming into vogue, and even many forms not neurotic are benefited. Labile galvanization of the affected part is usually employed, the poles being alternately active so as to secure to the greatest extent the catalytic effects of the current. Central treatment should not be neglected. In regard to *acne*, Bartholow says that "a cure can usually be effected by persevering treatment in the worst cases."

Chronic eczema, *psoriasis* and *prurigo* are other affections benefited by electricity. De Watteville has employed the same agent successfully in *local asphyxia*, *scleroderma* and *chilblains*.

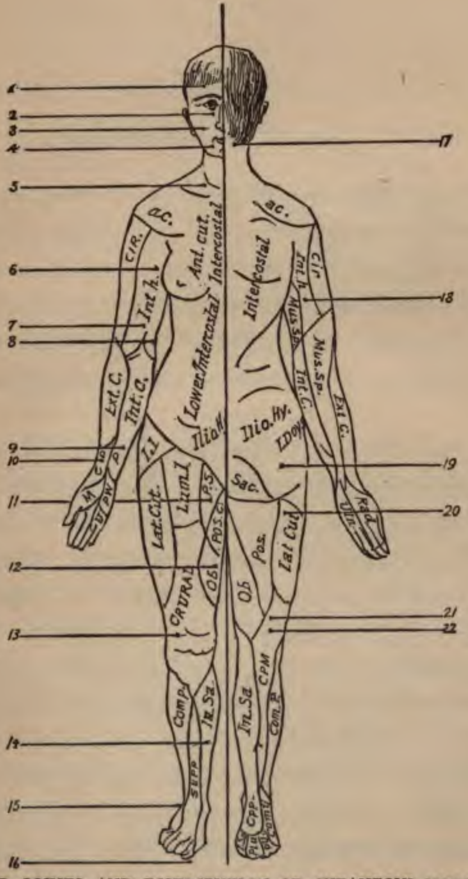
Alopecia is much benefited by galvanism, both poles being placed close together on the skin. The same treatment is useful in *bed-sores and ulcers*.

(*p*) **General Diseases.**—*Anæmia and chlorosis* are much benefited by the general methods of electrization, special attention being paid to subaural galvanization in chlorosis.

EXPLANATION OF FIG. 7.

1. Seventh or facial nerve supplying the frontal muscle.
2. " " " " levator labii superioris alæque nasi.
3. " " " " zygomaticus minor.
4. " " " " orbicularis oris and quadratur menti.
5. Phrenic nerve supplying the diaphragm.
6. Musculo-cutaneous nerve supplying biceps, brachialis, etc.
7. " " " " brachialis anticus.
8. Ulnar nerve supplying muscles of forearm and hand.
9. Radial " " flexors of thumb and fingers.
10. Ulnar " " palmaris brevis, abductor min. digit., opponens min. digit., etc.
11. Obturator nerve supplying sartorius, adductor longus, etc.
12. Crural " " adductor longus, vastus internus, etc.
13. " " " vastus externus.
14. Anterior tibial nerve supplying flexor com. digit.
15. Musculo-cutaneous nerve.
16. Internal saphenous nerve.
17. Occipital nerve supplying posterior neck muscles.
18. Musculo-spiral nerve supplying triceps, etc.
19. Intercostalis " " lumbar muscles.
20. Gluteus " " adductor magnus, etc.
21. Popliteal " " gastrocnemius externus.
22. " " " soleus.

FIG. 7.



MOTOR POINTS, AND DISTRIBUTION OF CUTANEOUS NERVES.

CHAPTER VI.

ELECTRICITY IN SURGERY.

For purposes of **electrolysis**, the external resistance being small, the internal resistance should not be great. Stöhrer's or Grenet's cells are employed, and the current should be accurately measured. The needles should be well insulated for two-thirds of their length, the remaining one-third being gilded to prevent its solution.

In the treatment of *aneurism*, our object is to secure, not decomposition, but coagulation of the blood. The clot formed about the anode being firmer, the needles are usually connected with this pole; their uninsulated portion is introduced completely into the sac in order to prevent diffusion of the current into the surrounding tissues, and the inflammation and sloughing which might result from such an accident. The kathode is placed at an indifferent point. The current strength should be sufficient to coagulate egg albumen in twenty to thirty minutes. Duration of sitting about thirty minutes, repeated according to results obtained. Great caution must be used in withdrawing the needles.

In the treatment of *nævi*, our object is to induce coagulation to such an extent as will facilitate absorption without causing sloughing. Usually one needle (kathode) will suffice. Begin with a few cells and gradually increase, if necessary. In *port-wine stain* we destroy the skin by introducing a number of needles superficially; the new skin is pale, but the cicatrix from a galvanic eschar does not contract.

Warts, moles, and single hair follicles may readily be destroyed by the kathodic needle.

Malignant tumors are treated by introducing a number of needles through the base; sloughing occurs, and the resulting ulcer heals by granulation. *Enlarged glands* and *small superficial tumors* are often successfully destroyed by electrolysis. In *cystic tumors* both needles are introduced, with the object of acting on the lining membrane, so as to facilitate absorption. Successful results have been thus obtained in *ovarian cysts, hydrocele, cystic goitre, hydatids of the liver*, etc.

By electrolysis, at least the growth of *fibroids of the uterus* can be arrested. The same means is very successful in causing the death of the fœtus and arrest of the growth of the cyst in *extra-uterine pregnancy*.

Excellent results have been obtained from electrolysis in the treatment of *stricture of the urethra*. A large bougie with a metallic point connected with the kathode is carried down to the stricture, while the other electrode is placed over the abdomen or perineum. Begin with 5–6 cells and gradually increase; repeat after a few days' interval, if necessary.

Galvano-causty.—For galvano-caustic purposes, a special electrode handle is employed, to which may be attached the loop, the cautery dome, or the knife. Its advantages are that it can be used in localities where other means would not be applicable; that it causes no hemorrhage, and that it is followed by less pain than cutting operations. The loop is of great service in the removal of *polypi of the larynx, nose, ear, uterus, and rectum*, also in removal of *hemorrhoids*, and in *amputation of tongue, penis, and cervix uteri*. It should be placed in position, then brought to a dull red heat, and gradually tightened as it cuts its way through.

The knife has been successfully employed for *tra-*

cheotomy, and for cutting through the vaginal wall into the cyst of a *tubal pregnancy*.

The cautery dome is applicable for all the purposes of an ordinary cautery, *to control hemorrhage, destroy hypertrophies, stimulate ulcers*, etc.

The Electric Light.—The incandescent wire is now being used in a variety of forms for the illumination of the various cavities of the body, for the purpose of examination as well as operation.

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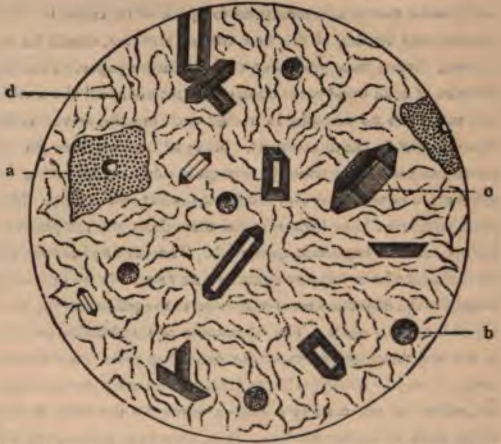

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